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**Abstract**

The focus of this project is to demonstrate the effectiveness of Amended Silicates™ sorbents as a mercury control technology for coal-fired power plants. The demonstration will be conducted at Cinergy's Miami Fort Unit 6 over a period of about eight weeks under typical plant operating conditions. Several trial campaigns will be completed: a parametric series of injection rates for the Amended Silicates sorbent to characterize its performance at the host site, an extended period (30 days) over which Amended Silicates sorbent is injected to evaluate long-term performance of the technology in an operating power plant, and an abbreviated series of injection rates with powdered activated carbon to serve as a basis of comparison. Samples of the host unit fly ash mixed with Amended Silicates sorbent will be extracted for testing as a cement replacement. A unique feature of the Amended Silicates sorbent is that its addition to a flue gas stream does not affect the salability of the collected fly ash plus sorbent as a pozzolan additive.

In this quarter preparation for the demonstration continued with completion of the draft demonstration plan and Cinergy site-access agreement. Work also started on the website shared database that will be used to provide project information between team members. Engelhard Corporation is finalizing the sorbent manufacturing protocol for sorbent production. A pilot run of Amended Silicates sorbent is being prepared for slipstream tests at an operation power plant in the next reporting period. Results from these tests will validate the manufacturing protocol prior to production of 50 tons of Amended Silicates sorbent for use in the demonstration. ASL also prepared and presented a summary of the project status to DOE at the July meeting in Pittsburgh, PA.

**TABLE OF CONTENTS**

<b>EXECUTIVE SUMMARY .....</b>	<b>1</b>
<b>INTRODUCTION .....</b>	<b>2</b>
<b>PROJECT DESCRIPTION .....</b>	<b>3</b>
PREPARATION .....	3
DEMONSTRATION .....	4
ANALYSIS .....	5
<b>PROJECT MILESTONES .....</b>	<b>6</b>
<b>PROJECT MANAGEMENT ACTIVITIES THIS QUARTER.....</b>	<b>6</b>
<b>EXPERIMENTAL.....</b>	<b>7</b>
<b>RESULTS AND DISCUSSION .....</b>	<b>7</b>
<b>CONCLUSIONS.....</b>	<b>7</b>
<b>REFERENCES .....</b>	<b>8</b>
<b>BIBLIOGRAPHY.....</b>	<b>8</b>
<b>LIST OF ACRONYMS AND ABBREVIATIONS .....</b>	<b>8</b>
<b>PLANNED ACTIVITIES FOR NEXT QUARTER .....</b>	<b>8</b>

## Executive Summary

The Amended Silicates™ sorbent technology is a mercury control material that is a direct replacement for activated carbon. Amended Silicates sorbent is a powdered material similar to carbon injected upstream of existing particulate control equipment for rapid and effective capture of vapor-phase mercury in the flue gas stream. This technology has been under development with funding from the EPA and DOE, and has achieved success in demonstrating the sorbent at a pilot scale on a slipstream from a Colorado power plant and in a short-term trial at a coal-fired unit of Xcel Energy. This demonstration of Amended Silicates™ sorbents will evaluate the use of injected particulate sorbents to control of mercury emissions from Cinergy's Miami Fort Unit 6 for a period of six weeks under various conditions. A consortium has been established to support the technical and financial requirements imposed by a long-term test of this technology. The consortium includes utilities with an interest in cost-effective mercury control technologies, mercury control technology suppliers (i.e., Amended Silicates, LLC and its parent companies); Engelhard Corporation for manufacture of the AS sorbent for the trial; the University of North Dakota Energy and Environmental Research Center to lead the mercury measurement effort; a modeler to provide insight into the fluid mechanics of sorbent injection; with strong interest on the part of EPRI and the American Public Power Association.

The project has been defined in three stages: **preparation**, which incorporates all activities to prepare the host site for the demonstration, as well as the manufacturing of 50-100 tons of Amended Silicate™ sorbent; **demonstration**, where a matrix of sorbent injection cases will be conducted; and **analysis**, during which all the collected data will be correlated, analyzed, and interpreted to provide quantitative information regarding the performance of the Amended Silicate™ sorbent at a commercial scale. ADA has established a series of milestones for these three stages as delineated in this report.

In this quarter, ASL has been worked closely with our new strategic manufacturing partner, Engelhard Corporation, to finalize and advance the manufacturing process to produce a cost-effective and high-quality sorbent product. Identifying appropriate equipment for the process will determine which manufacturing facility will be used for making the 50 tons of Amended Silicates (AS) sorbent. Results to date have identified Engelhard's Elyria, OH plant as best site to manufacture the trial AS sorbent in December 2005.

In July, ASL presented a project status briefing at DOE/NETL's annual Mercury Program Review. The presentation covered activities in the previous year and discussed plans for the completion of the demonstration trial in the first quarter of 2006. The addition of Engelhard as a strategic partner for manufacturing was noted and their qualifications for such a role were outlined. Progress was made towards finalizing the Demonstration Plan and Site-Access Agreement. Draft versions of the two documents were given to Cinergy for review. The final versions of these documents will be published in November.

In September, ASL team members from ADA Technologies, Inc. and CH2M HILL met to discuss the configuration of the website project database. The secured website will be accessible by team members only with various security levels to limit access as deemed appropriate. Parameters of interest for posting to the website were identified for the Ontario-Hydro data, SCEM mercury data, plant operations data, and analytical data. The team members envision the database to contain selectable tabs for viewing status of the demonstration effort,

presenting QA/QC approved mercury data, and displaying graphs showing relationships between plant operations and mercury removal.

## Introduction

Amended Silicates, LLC, has been awarded a project to demonstrate its Amended Silicates™ mercury removal sorbent technology in a full-scale trial at a coal fired power plant. The trial is to be hosted by Cinergy at a site in Ohio and funded in part by US Department of Energy's National Energy Technology Laboratory (NETL).

The Amended Silicate™ sorbent technology, a direct replacement for activated carbon, is a powdered sorbent injected upstream of existing particulate control equipment for rapid and effective capture of vapor-phase mercury in the flue gas stream. This technology has been under development with funding from the EPA and DOE, and has achieved success in demonstrating the sorbent at a pilot scale on a slipstream from a Colorado power plant and in a short-term trial at a coal-fired unit of Xcel Energy.

The Amended Silicate™ sorbents use silicate minerals as substrate particles on which a chemical reagent with a strong affinity for mercury and mercury compounds is impregnated. Because of their physical construction, these silicates present extended surface area on each particle combined with an easily-generated particle size of a few microns. This configuration promotes maximum exposure of the chemical amendment to the mercury vapor present in the coal-fired flue gas stream. The base silicate materials typically sell for *4-8¢ per pound*, so they represent a very cost-effective sorbent material. In addition, because of their silicate content, they have been shown to allow the continued sale of fly ash as a pozzolan material. Tests completed by Boral Materials Technologies have indicated that there is no effect on fly ash use in concrete due to the addition of Amended Silicate™ sorbents, in dramatic contrast to the effect of powdered activated carbon injection.

To support EPA's announced emissions regulations for mercury from coal-fired power plants, NETL solicited proposals and selected eight cost-shared projects to demonstrate mercury control concepts at a commercial scale. The objective of the program is to gather data to document the performance of mercury control technology alternatives when installed and operated at full-scale (100-MW or greater) generating units. One of the selected proposals is for the demonstration of Amended Silicates™ sorbent technology.

This demonstration of Amended Silicate™ sorbents will evaluate the control of mercury emissions from Cinergy's Miami Fort Unit 6 under various conditions. A consortium has been established to support the technical and financial requirements imposed by a long-term test of this technology. The consortium includes utilities with an interest in cost-effective mercury control technologies, especially those that permit continued sale of fly ash as a pozzolan material; mercury control technology suppliers (i.e., Amended Silicates, LLC and its parent companies); an organization to lead the mercury measurement effort; a modeler to provide insight into the fluid mechanics of sorbent injection; and other interested parties.

Amended Silicates, LLC, is a joint venture company formed by ADA Technologies and CH2M HILL that is focused on the commercialization of Amended Silicate™ sorbent. Amended

Silicates, LLC is completing negotiations with Engelhard to manufacture the large quantities of Amended Silicate sorbent needed for the demonstration. The Amended Silicates team will lead the technical effort of the project. Cinergy has offered its Miami Fort Unit 6 as a host site, and will provide on-site technical support during injection of the sorbent material as a cost-share contribution. The mercury semi-continuous emissions monitors (SCEMS) will be provided by the University of North Dakota's Energy and Environmental Research Center (UNDEERC), and the Ontario-Hydro wet chemistry testing will be conducted by Western Kentucky University (WKU). Boral Materials Technologies will perform tests of the collected sorbent plus fly ash to assess the impact of the added sorbent on the use of fly ash as a concrete additive. The ability to continue to sell fly ash is one of the significant advantages of Amended Silicate™ sorbents in comparison to activated carbon.

## Project Description

This trial demonstration project is intended to show the effectiveness of Amended Silicate™ sorbent as a mercury control technology, including the ability to maintain fly ash sales from plants implementing its use. The project will incorporate three sorbent injection campaigns: one where powdered activated carbon is injected for a base-comparison case, a second where Amended Silicates sorbent is injected over a range of rations to establish process parameters required to meet mercury control targets, and a third where Amended Silicate sorbent is injected for a contiguous period of 30 days to validate long-term consistent performance and to discover any impact on balance of plant operation.

There are two major objectives for the full-scale demonstration project. The first is to demonstrate the ability of Amended Silicate™ sorbent to control emissions of mercury from commercial coal-fired power plants over a typical range of operating conditions for an extended period of time. The data analyses will be extensive, and will include computation of mercury removal rates and the efficiency of Amended Silicate™ sorbents in these applications. The second objective is to show that fly ash mixed with AS sorbent is compatible with its use as a pozzolan replacement in concrete.

The project has been defined in three stages: **preparation**, which incorporates all activities to prepare the host site for the demonstration, as well as the manufacture of 50 tons of Amended Silicate™ sorbent; **demonstration**, where a matrix of sorbent injection cases will be conducted; and **analysis**, during which all the collected data will be correlated, analyzed, and interpreted to provide quantitative information regarding the performance of the Amended Silicate™ sorbent at a commercial scale.

There are specific activities to be carried out in each stage of the project, as described below.

### **Preparation**

- Project planning, including placement of subcontracts with team members and negotiation of a host site agreement with Cinergy.

- Development of a project schedule that reflects availability of the site, subcontractors, and time needed to prepare a commercial quantity of Amended Silicate sorbent.
- Site preparation, including the selection of locations for flue gas sampling ports and sorbent injection ports, and for the installation of a sorbent injection system to supply sorbent to the injection lances.
- Completion of a computational fluid dynamics modeling study to evaluate options for the number and locations of sorbent injection lances.
- Acquisition of a leased sorbent injection skid, fabrication of injection lances, and installation of the full sorbent injection system.
- Transport and installation of the semi-continuous mercury emissions monitors upstream of sorbent injection and at the outlet to the Unit 6 electrostatic precipitator.
- Prepare 50 tons of Amended Silicate sorbent for use in the trial. This activity includes selection of a strategic partner to manufacture the sorbent, and oversight by Amended Silicates, LLC to assure quality control and consistency of the final product.

### ***Demonstration***

In the demonstration phase a series of campaigns will be completed with different sorbents to characterize their performance in the capture of mercury from flue gas at Miami Fort Unit 6. Mercury CEMs will be operated throughout the demonstration phase to collect data on mercury concentrations upstream of sorbent injection and at the outlet of the ESP of the host unit. At four discrete times in the demonstration, Ontario-Hydro wet chemistry sampling will be performed as a check against the mercury CEMs data. The specific mercury removal measurement campaigns are described below.

- Baseline mercury removal characterization for the host unit over a two week period.
- Injection of Amended Silicate sorbent in a parametric series of trials, to characterize performance in the host unit under a range of operating conditions. Target mercury removal rates will be 55% and 80% for this nominal ten-day trial.
- Return to normal operations (no sorbent injection) for a period of one week to re-establish a baseline before initiation of a longer-term trial of Amended Silicates sorbent.
- Extended trial of Amended Silicate sorbent for a period of 30 days to evaluate performance and impact on balance of plant equipment.
- Injection of powdered activated carbon as a mercury sorbent on Miami Fort Unit 6. This campaign will run for one week, with target mercury removal rates of 55% and 80%.



- During each campaign, samples of fly ash mixed with mercury sorbent material will be extracted from the Host Unit ESP for use in tests to determine the effect of the sorbent on the use of the mixture as a pozzolan replacement in the manufacture of concrete.

## ***Analysis***

The use of CEMS results in the acquisition of a substantial quantity of data over the demonstration phase of the project. This information will be subject to a rigorous QA/QC review protocol, then archived to a project website where it will be accessible to project team members. This website will provide the home for a project database to be used to correlate mercury removal results with operating conditions of the host unit and performance of the particulate control equipment. The intent is to exploit the website to facilitate access to the data on a timely basis throughout the project. Specific activities to be carried out in the Analysis phase are noted below.

- Prepare and execute a QA/QC plan for the project.
- Establish a project website as a mechanism to share information and coordinate analysis of posted results.
- Create a project data base as a location to which all pertinent information on trials can be transferred for secure storage and analysis.
- Perform routine QA/QC screening of data and add qualified data to the project data base.
- Review and analyze trial data in the project data base to establish performance measures and trends in the data set.
- Analyze samples of fly ash plus sorbent to document the effect of sorbent addition on the use of fly ash as a cement replacement in concrete.
- Supply samples of fly ash to DOE contractor for leachate and mercury stability testing.
- Prepare reports as required by the Cooperative Agreement.
- Prepare technical papers that document the results of the trial demonstration.
- Overall management of the project with respect to scope, schedule, and budget.

Project activities are being carried out by technical personnel from the two parent companies of Amended Silicates, LLC. Jim Butz of ADA Technologies serves as Principal Investigator for the project with strong technical support from CH2M HILL and the other members of the consortium. Tom Broderick of ADA will serve as the lead engineer for the project team at the host site during the trial. Joe Hammond of CH2M HILL will direct the site engineering activity for the installation of the sorbent injection system and mercury CEMs.

## Project Milestones

The milestones below were recently revised and approved by DOE as well as modification to the previous schedule.

- **April, 2004:** Cooperative agreement signed by Amended Silicates, LLC and project initiated.
- **August, 2004:** Subcontracts in place, project team coordinates schedule.
- **March, 2005:** Joint Development agreement negotiated with Engelhard Corporation to become strategic manufacturing partner to Amended Silicates, LLC.
- **April 2005:** Engelhard begins preparation of sorbent samples to evaluate manufacturing process revisions on final sorbent product. Short-term cooperative effort between ADA and Engelhard technical staffs initiated.
- **July 2005:** Production process modifications identified for preparation of 50 tons of Amended Silicates sorbent to be used in Cinergy demo.
- **September 2005:** Scale-up production trial to manufacture nominal 100-lb quantity.
- **October 2005:** Begin planning for full-scale production of Amended Silicates sorbent.
- **December 2005:** Deliver Amended Silicates sorbent to Miami Fort Station.
- **First Quarter, 2006:** Begin injection trial.
- **Second Quarter 2006:** Submit samples of fly ash plus sorbent for analysis of suitability for use in concrete.
- **Second Quarter 2006:** Samples provided for leachate and stability testing.
- **July 2006:** Data analyses completed.
- **Second half of 2006:** Presentation of results at technical conferences.

## Project Management Activities This Quarter

This report documents project activities that occurred between July 1 and September 30, 2005. For this period, work consisted of tasks in the Preparation phase and Analysis phase. During this quarter, members of the project team traveled to Pittsburgh, PA in July to present project status at the annual DOE Mercury Program Review. Topics of interest covered in the meeting included a technical presentation outlining the injection demonstration program and a revised schedule for sorbent manufacturing and subsequent sorbent injection campaigns at the host site.

A license agreement between ASL and Engelhard for the manufacture and market of Amended Silicate sorbent material is completing negotiations. Currently Engelhard is optimizing the sorbent formulation and preparing a full-scale production sorbent manufacturing protocol

under a Joint Development Agreement. The optimized sorbent formulation has been established and efforts are now being directed towards sorbent manufacturing. Test batches of sorbent are being made to establish the most effective equipment for the improved manufacturing process. Samples of these pilot batches are being tested in cooperation with Western Kentucky University (WKU) in laboratory and coal-fired slipstream test fixtures. The decision on which manufacturing plant is most appropriate to produce Amended Silicate sorbent will be made in early November. Following that decision, 100 pounds of sorbent material will be made for a long-term pilot-scale test. Results from the pilot-scale tests will validate the sorbent manufacturing protocol and work will begin to produce 50 tons of Amended Silicates sorbent.

A draft Demonstration Plan for the sorbent injection trials at Miami Fort Unit 6 was completed this quarter. The draft was given to Cinergy for review and comment. A draft version of the Site Access Agreement was also sent to Cinergy for legal review. Both of these documents will be finalized before the start of sorbent injection at the site. Documents are expected to be finalized in November. CH2M HILL will complete the installation engineering for the sorbent injection system in the next quarter. Cinergy will also make arrangement with Norit Americas to lease a Porta-Pac injection system in the upcoming quarter.

During the demonstration experimental data will be collected and made available to project team member via a secured website. This past quarter a meeting was held with team members ADA Technologies, Inc. and CH2M HILL to discuss the components needed for the website. The primary component of the site is an information database containing Ontario-Hydro and mercury SCEM data, plant operational and environmental CEM data, analytical results for coal and flyash materials, and sorbent injection data. Another component of the site will be a page that gives team members current status of the project showing completed, current and pending activities at a glance. Team member will be required to enter a password to gain access to the site. Additional security clearances for access to more sensitive areas of the site such as data input screens and viewing information under review pending release will be required. One other feature that will be incorporated into the site is a page that will show correlations between operational parameters and mercury removal. Configuration of the website will be finalized late in the upcoming quarter.

## **Experimental**

No activities in this area.

## **Results and Discussion**

None to report.

## **Conclusions**

None to report.

## References

None.

## Bibliography

None.

## List of Acronyms and Abbreviations

ADA	ADA Technologies, Inc.
AS	Amended Silicates
ASL	Amended Silicates, LLC
CEM	Continuous Emissions Monitor
CFD	Computational Fluid Dynamics
CH2	CH2M HILL
DOE	Department of Energy
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESP	Electric Static Precipitator
JDA	Joint Development Agreement
LLC	Limited Liability Company
NETL	National Energy Technology Laboratory
NPDES	National Pollution Discharge Elimination System
QA/QC	Quality Assurance/Quality Control
SCEM	Semi- Continuous Emissions Monitor
SS	Settleable Solids
TSS	Total Suspended Solids
UNDEERC	University of North Dakota's Energy and Environmental Research Center
US	United States
WKU	Western Kentucky University

## Planned Activities for Next Quarter

The next quarter of the project will see continued efforts in the planning and analysis phases in preparation for the demonstration phase, including the following elements:

- A focused effort to finalize the large-scale manufacturing protocol. A hundred pounds of sorbent will be produced for pilot-scale testing at Cooper Station in cooperation with WKU. Production of the 50 tons of Amended Silicates sorbent required for the Cinergy demonstration is scheduled for completion by mid-December of 2005. All pilot materials will be subjected to extensive testing to characterize performance as a mercury sorbent and properties required for effective use in the demonstration project.
- Execution of a host site access agreement with Cinergy Services. ADA will lead this effort.

- Revision and release of the demonstration plan and associated sampling protocols. This document will serve as a guide for the trial activities to be carried out in the first quarter of 2006. ADA Technologies to lead this effort.
- Prepare a detailed schedule for final site preparation and execution of the sorbent injection trial as described in the demonstration plan. ADA to lead this effort.
- Finalize the configuration of the web site database.
- Fabrication and installation of sorbent injection lances. CH2M HILL to lead the fabrication effort and Cinergy is responsible for installing the lances.
- Secure a Porta-Pac sorbent injection system from Norit Americas and install the system at Miami Fort Unit 6 boiler.